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A comprehensive review on prevention and management of hospital-acquired infections: Current strategies and best practices

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Abstract

Hospital-acquired infections (HAIs) are a significant global public health issue, impacting millions of patients annually. Another name for HAIs is nosocomial infections (NI).These infections arise from illnesses that patients contract while they are in the hospital and can have major negative effects on their health, such as increased morbidity, prolonged hospital stays, or even death. The rise of antibiotic-resistant pathogens has only added to the complexity and severity of HAIs. Healthcare facilities need to take a thorough, evidence-based strategy to HAI prevention and control in order to solve this issue. This entails carrying out evidence-based procedures, like cleaning the environment, using the proper antimicrobial agents, and practicing hand hygiene, in addition to continuously assessing and evaluating their HAI prevention program. Improving patient outcomes, cutting healthcare costs, and preserving public confidence in the healthcare system all depend on lowering the prevalence of HAIs. Improvements in hospital epidemiological surveillance, infection control practices, and the implementation of HAI prevention guidelines should lead to a decrease in the frequency of morbidity and mortality. Nonetheless, HAIs continue to be a major worry for high-risk populations.

Keywords: Hospital-acquired infections; Nosocomial; Healthcare facilities; Infection control

1. Introduction

Hospital-acquired infections (HAIs) are a major public health concern, affecting millions of patients worldwide each year[1].HAIs are also termed as Nosocomial infections(NI).These infections occur when patients acquire an infection during their hospital stay and can lead to serious health consequences, including increased morbidity, longer hospital stays, and even death[2]. HAIs are caused by a variety of pathogens, including bacteria, viruses, and fungi, and can be transmitted through various means, such as contact with contaminated surfaces, equipment, or healthcare personnel[3]. The rise of antibiotic-resistant pathogens has only added to the complexity and severity of HAIs .

In order to address this problem, healthcare facilities must adopt a comprehensive and evidence-based approach to HAI prevention and control[2]. This includes implementing evidence-based practices, such as hand hygiene [4], environmental cleaning [5], and the use of appropriate antimicrobial agents [6], as well as continuous monitoring and evaluation of their HAI prevention program[7], Reducing the incidence of HAIs is crucial for improving patient outcomes, reducing healthcare costs[8], and maintaining public trust in the healthcare system.

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2. Sources of Hospital-Acquired Infections:[1]

- **Healthcare Workers**: Healthcare workers play a crucial role in preventing the spread of HAIs. However, they can also be a source of infections if they do not follow proper hand hygiene and other infection control practices. This can include failure to clean hands before and after patient contact, as well as wearing contaminated gloves or gowns.
- **Medical Devices**: Medical devices such as catheters, ventilators, and other equipment can be a source of HAIs if they are not properly cleaned and disinfected between uses. Bacterial and fungal infections can occur when contaminated devices are used on multiple patients.
- **The Environment**: The hospital environment can also be a source of infections. This can include contaminated surfaces, air conditioning systems, and water supplies. Proper cleaning and disinfection of the hospital environment is essential to prevent the spread of HAIs.
- **Patients**: Patients themselves can also be a source of HAIs. This can occur when they are colonized with bacteria or viruses that can be transmitted to other patients. Patients with weakened immune systems are particularly vulnerable to these infections.

2.1. Pathogens causing HAI or Nosocomial infections

Nosocomial infections are a major public health concern, as they occur in healthcare facilities and can have severe consequences for patients, especially those with weakened immune systems. Several microorganisms have been identified as the most common causes of nosocomial infections.

- ***Escherichia coli***: *E. coli* is a type of bacteria commonly found in the human gut, but it can also cause nosocomial infections, especially in patients who have recently undergone surgical procedures. The bacteria can cause urinary tract infections, bacteremia, and wound infections [9].
- ***Staphylococcus aureus***: *S. aureus* is a type of bacteria that is commonly found on the skin and in the nasal passages. It can cause a range of infections, including skin and soft tissue infections, pneumonia, and sepsis[10].
- ***Klebsiella pneumoniae***: *K. pneumoniae* is a type of bacteria commonly found in the gut, but it can also cause nosocomial infections, especially in patients who have been hospitalized for a prolonged period of time. The bacteria can cause pneumonia, urinary tract infections, and bloodstream infections[11].
- ***Acinetobacter baumannii****: A. baumannii* is a type of bacteria that is commonly found in soil and water. It can cause a range of infections, including pneumonia, urinary tract infections, and wound infections[12].
- ***Candida****: Candida* is a type of yeast that is commonly found in the human body. It can cause infections in various parts of the body, including the skin, mouth, throat, and genital area[13].
- ***Clostridium difficile*** *(C. difficile*): Important nosocomial pathogen *C. difficile* primarily causes diarrhea in patients. The United States, Canada, and Europe have all recorded many cases of *C. difficile*. It is a Gram positive and anaerobic bacteria that produces spores. It typically colonizes in gastrointestinal tract and contributes to the normal microbiota. Colitis and 15%–25% of instances of diarrhea are brought on by the toxins generated by *C. difficile*. Toxins, fimbriae, capsules, and hydrolytic enzymes are the main virulence components of C. difficile[14].
- ***P. aeruginosa***: Due to several mechanisms that fight back against antibiotics, *P. aeruginosa* is developing antibiotic resistance. These strategies consist of modified targets for antibiotics, poor drug absorption, and drug modification. Treatment of *P. aeruginosa* infections is complicated as a result of this emerging resistance. Cephalosporins, trimethoprim, macrolides, chloramphenicol, tetracyclines, and fluoroquinolones are some of the medications that are presently ineffective as a consequence of increasing resistance[14].

2.2. Mode of transmission of HAIs

- ***E. coli***: *E. coli* can be transmitted through person to person, environment or contaminated water and food[15].
- ***S. aureus****: S. aureus* can spread by physical contact with infected people or contact with shared objects and surfaces such door knobs, benches, towels, and taps[15].
- ***K. pneumoniae*** *: K. pneumonia* can spread from person to person in hospitals, especially when medical personnel don't wash or disinfect their hands after touching a sick patient. Catheters, open wounds, or respiratory devices may be the source of its dissemination. According to reports, patients might spread K. pneumoniae through their hands (42%), throat (19%), and stool (77%)[15].
- ***Acineto bacterbaumannii****: Acineto bacterbaumannii* is an omnipresent pathogen known as a major agent in healthcare and nosocomial-associated infections. It can spread by contact with a person or environment that has the bacteria. In healthcare facilities, the bacteria can spread from workers' hands or contaminated surfaces or healthcare items[12].

- ***Candida***: In healthcare facilities, candida can spread from person to person either through contact with infected environmental surfaces or equipment[13].
- ***C. difficile*** *:C. difficile* spores can survive for months and cause issues for cleaning and disinfecting products. The main sites acting as reservoirs are inanimate objects and sick intestinal patients. A greater role is being played by hospital workers and the hospital environment[15].
- ***P. aeruginosa***: Breast pumps, incubators, sinks, medical personnel hands, and hand soaps are significant sources of infection[15].

2.3. Strategies for Prevention of HAI's

Preventing HAIs is a critical aspect of healthcare to improve patient safety and reduce healthcare costs. Here are some effective strategies for the prevention of healthcare-associated infections

2.3.1. Hand Hygiene

Proper hand hygiene, including hand washing with soap and water or using hand sanitizers, is one of the most effective ways to prevent the spread of infections in healthcare settings.

2.3.2. Infection Control Practices

Implement and enforce strict infection control protocols, including proper handling and disposal of sharps, appropriate use of personal protective equipment (PPE), and safe handling of contaminated materials.

2.3.3. Environmental Cleaning and Disinfection

Regular and thorough cleaning and disinfection of patient care areas, equipment, and frequently touched surfaces can help prevent the spread of infections.

2.3.4. Antibiotic Stewardship

Implement and promote appropriate use of antibiotics to prevent the development of antibiotic-resistant bacteria, which can lead to difficult-to-treat infections.

2.3.5. Isolation Precautions

Use appropriate isolation precautions for patients with known or suspected contagious infections to prevent the transmission of pathogens to other patients and healthcare workers.

2.3.6. Education and Training

Provide ongoing education and training to healthcare staff regarding infection prevention measures, protocols, and updates on emerging infectious diseases.

2.3.7. Immunization Programs

Encourage and facilitate healthcare workers and patients to receive appropriate vaccinations to reduce the risk of vaccine-preventable infections.

2.3.8. Patient Engagement

Educate patients and their families on infection prevention measures, such as proper hand hygiene, and encourage them to be proactive in their own care.

2.3.9. Medical Device Safety

Ensure proper insertion, care, and maintenance of medical devices (e.g., catheters, ventilators) to minimize the risk of device-related infections.

2.3.10. Surveillance and Reporting

Establish a robust surveillance system to monitor and report HAIs, enabling timely interventions and the identification of trends and areas for improvement.

2.3.11. Waste Management

Implement safe and proper handling, storage, and disposal of medical waste to prevent the spread of infections through contaminated waste.

2.3.12. Patient Placement and Flow

Optimize patient placement and flow within healthcare facilities to minimize the risk of cross-contamination and transmission of infections.

2.3.13. Compliance Monitoring

Implement a system to monitor and ensure compliance with infection prevention practices and protocols, and provide feedback to healthcare staff for improvement.

2.3.14. Collaboration and Communication

Foster collaboration and communication among healthcare staff, departments, and facilities to ensure a unified approach to infection prevention and control.

2.3.15. Research and Innovation

Encourage research and innovation to develop new technologies and practices that can further enhance infection prevention efforts.

2.4. Strategies for Management of HAI's

Before microbiology is available, any NI must be treated with an empiric antibiotic regimen.

- Regularly collected surveillance data on the dominating organisms in hospitals and intensive care units.
- Monitoring of these species' existing resistance patterns
- Finding NI outbreaks linked to one or more common pathogens.

2.4.1. Principles of Empiric Therapy

To ensure that the majority of the suspected infections are covered, the traditional empiric therapy must be sufficiently broad. The first official suggested regimen for combination therapy has historically been an antipseudomonal penicillin (piperacillin) plus an aminoglycoside or an antipseudomonal cephalosporin (Ceftazidime) plus an aminoglycoside. However, the use of a glycopeptide is a component of empiric therapy in scenarios suggestive of gram positive organisms like MRSA (in institutions where this organism is endemic). Most gram positive organisms are also protected against by rifampicin and fusidic acid Streptogramins (Quinupirstin- Daltopristin).

Carbapenems (such as imipenem or meropenem) in combination with either an aminoglycoside (amikacin) or a fluoroquinolone (Ciprofloxacin) should be advised during outbreaks of NI with high probability of cross contamination of a previously identified endemic multi-resistant organism, such as Pseudomonas aeruginosa. Any empirical treatment should be evaluated again 2 or 3 days after starting. Based on the results of antibiotic sensitivity tests that become available on days 2 or 3 and the patient's clinical response, the course of treatment should be changed. When the patient's clinical condition warrants it, switching to a less expensive or toxic antibiotic or choosing a more appropriate combination therapy is advised.

Specific Empiric Situations

- The inclusion of Clindamycin, Cefoxitin, or Metronidazole is advised when anaerobic bacteria are suspected, as in postoperative abdominal polymicrobial infection or aspiration pneumonia. A good alternative for mixed aerobic and anaerobic infections is imipenem.
- Erythromycin and rifampicin, either alone or in combination, are the antibiotics of choice if Legionellosis (atypical pneumonia) is suspected.
- Patients with neutropenia who have a temperature of 38.3°C or below and a neutrophil count of 500/m3.

2.4.2. Initial Antibiotic Therapy

- Ceftazidime + vancomycin(only if suspected causative agent is MRSA Penicillin resistant pneumococci or other gram positive resistant organisms).

- Ceftazidime, Imipenem, Cefpime, or meropenemmono therapy is used if Vancoymycin is not necessary.
- If a combination is required, Ceftazidime plus an antibacterial penicillin (such as Piperacillin) should be used [16][17].

Treatment Options for Established Nosocomial Infections:[18,19,20]

Table 1 Gram Negative Organisms

	E.coli	***Klebsiellaspp: SBL -***	***ESBL+***	***Enterobacter spp.***	***Pseudomonas aeruginosa***
Monotherapy	Ceftazidime or aztreonam or cefpirome/cefepime: amoxicillin-clavulanic acid: fluoroquinolone (in UTI)	Ceftazidime or : cefoperazone or cefepime/cefpirome amoxicillin-clavulanic acid	Imipenem or cefepime: fluroquinolone (in UTI)	Imipenem or meropenem: cefpirome/cefepime: piperacillin + tazobactam	Penicillins (ticarcillin, piperacillin, azlocillin). Cephalosporins (ceftazidime, cefpirome/cefepime) Imlpenem, meropenem
Conventional combinations	Cefotaxime + amikacin: piperacillin + tazobactam: cefoxitin or aztreonam + aminoglycoside	Piperacillin + tazobactam: ticarcillin + clavulanic acid: cefotaxime + aminoglycoside	Imipenem + aminoglycoside: piperacillin + tazobactam + amikacin	Third generation cephalosporin + aminoglycoside: aztreonam + amikacin	Ticarcillinaztreonam or ceftazidime + sulbactam + tobramycin or amikacin: ceftazidime + fluoroquinolone
Alternative threatment	Imipenem alone Imipenem + aminoglycoside imipenem + fluoroquinolone	Imipenem alone Imipenem + aminoglycoside : imipenem + fluoroquinolone	Imipenem + ciprofloxacin	Imipenem + fluoroqulnolone: aminoglycoside + ciprofloxacin	Antipseudomonal penicillin + fluoroquinolone: aztreonam + amikacin: aminoglycoside + ciprofloxacin: fosfomycin + ciprofloxacin

Table 2 Gram Positive Organisms

	Staphylococcus aureus: MSSA (methicillin-susceptible)	***MRSA (methicillin-resistant)***	***Coagulase-negative staphylococci***	***Enterococcus spp.***
Monotherapy	Penicillins, cloxacillin: cefazolincefalothin: Second generation cephalosporin: cefotaxime aminoglycosides	Vancomycin: imipenem-cilastatin: meropenem: fusidic acid	Same indications as for MRSA, with higher resistance rates to: Quinolones, Aminoglycosides, Clindamycin. cotrimoxazole.	Ampicillin: imipenem: piperacillin: glycopeptide (in nosocomial UTI only)
Conventional combinations	Penicillin + aminoglycoside (oxacillin + gentamicin):	Rifampicin + vancomycin: fusidic acid + glycopeptide:		Ampicillin + gentamicin: vancomycin + aminoglycoside

	tetracycline + aminoglycoside: amoxicillin + clavulanic acid: ampicillin + sulbactam	fosfomycin + aminoglycoside: vancomycin + fluoroquinolone		
Alternative threatment	Fluoroquinolone + fusidic acid: fosfomycin + L-lactam: + fusidic acid + cloxacillin	Imipenem + vancomycin: fusidic acid + fosfomycin: fusidic acid + glycopeptide: fusidic acid + rifampicin:	Imipenem + fosfomycin: aminoglycoside	Teicoplanin + penicillin: imipenem + glycopeptides: piperacillin + teicoplanin

3. Conclusion

The frequency of morbidity and mortality should decline as a result of improvements in hospital epidemiological surveillance, infection control procedures, and application of guidelines for HAIs prevention. HAIs still poses a serious concern to high-risk individuals, nevertheless.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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